A Thesis for the Degree of Ph.D. in Engineering

Design and Fabrication of a Tooth-Inspired Tactile Sensor for the Detection of Multidirectional Force

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Thesis Abstract

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Thesis Title

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Thesis Summary

Demands on tactile sensors have been increasing rapidly. When they are thin and flexible, they can be attached to arbitrary surfaces and contribute to enhance precision in monitoring and handling objects. A capacitive-type tactile sensor with liquid dielectric is proposed to achieve both high accuracy and flexibility. There also are demands for tactile sensors that can detect multidirectional load in a narrow space. For such applications, the tactile sensors cannot have shapes of a sheet or a pad as reported in many of the previous work. Thus, in this thesis, a tactile sensor that has a three-dimensional format and can detect multi-directional force is designed and demonstrated, which is inspired by the anatomy of a tooth.

Chapter 1 summarizes background of the research. Tactile sensors are thoroughly surveyed, among which the highly accurate and flexible tactile sensor is detailed. The objective of this work is explicitly described.

Chapter 2 illustrates the design strategy of the sensor device. The inspiration of the design of the sensor, which is a tooth, is discussed.

Chapter 3 explains the design of the sensor device. The sensor consisted of a center pole that acts like a tooth, which can sense the direction of light touch or pressure applied on its enamel. The bottom of the center pole is equipped with four strain gauges, whose resistances change according to the movement of the center pole.

Chapter 4 illustrates the fabrication and assembly processes of the sensor device. The center pole is made of stainless-steel and is plugged into an acrylic base, just like a tooth that is plugged in the alveolar bone. The assembly process allows the sensor to have the strain gauges in a three-dimensional manner, which support the pole and detect the shear force applied to the pole.

Chapter 5 describes the experimental results. The sensitivity of the sensor device per unit 1 mm displacement is deduced to be -0.016 mm^{-1}, while sensitivity per unit 1 N load is -0.313 N^{-1}. The sensor is verified to be capable of detecting the magnitude and direction of the multidirectional load.

Chapter 6 summarizes the result of this study.